Commensal Activity as a Function of Age
in Two Species of California Abalones

(Mollusca : Gastropoda)

BY

JOHN C. HANSEN

Moss Landing Marine Laboratories, Moss Landing, California　95039

(2 Plates; 2 Text figures)

INTRODUCTION

THE PURPOSE OF THIS STUDY was to determine the value of commensal activity as a function of relative age in shells of two species of California abalones. The vacant shells of two species of California abalones (Haliotidae), *Haliotis rufescens* SWAINSON, 1822 and *H. cracherodii* LEACH, 1817 were chosen for this study for their abundance in a large size range (2.1 cm to 21.0 cm) at the location of collection, the beaches of Año Nuevo Island, 63 km south of San Francisco in San Mateo County, California. Because of the large number of shells of all sizes required for this type of study, shells of animals that had died of natural causes were used rather than a collection of shells of living animals.

The red abalone, *Haliotis rufescens,* is primarily a sublittoral species and is the largest and commercially most important species of California haliotids. The black abalone, *Haliotis cracherodii,* is somewhat smaller than the red abalone and is found living in the eulittoral and shoal sublittoral areas.

Two of the most common animals that live commensally on the shells of many marine gastropods are *Clione celata* GRANT, var. *californiana* DE LAUBENFELS, 1932, a boring sponge (Porifera), and *Penitella conradi* VALENCIENNES, 1846, a piddock or boring clam. *Cliona celata californiana,* a member of the family of lime-boring sponges, the Clionidae, is yellow in color and lives commensally on the shells of a number of species of mollusks and cirripeds. This sponge bores a vast network of tunnels in its host's shell to increase surface area for attachment (MacGINITIE & MacGINITIE, 1949). The sponge borings can greatly reduce shell strength. I have found that the infection by *C. celata californiana* invariably begins in the protoconch area of gastropods and in the umbonal area of bivalves. These are the oldest and most weathered areas of the shells and are therefore the most vulnerable to the initial attack by the sponge. The sponge then spreads from these initial areas and often reduces the host shell to a fragile skeleton. Typical infestations by *C. celata californiana* on shells of *Haliotis rufescens* are shown in Figures *1*a, *1*b, and *2*a, *2*b [E]. In Figure *1*a infection had begun in the protoconch area at the top of the shell. The infection had spread from the protoconch area in Figure *1*b. It appears as stippling near the top of the shell. Nearly 50% of the shell surface in Figure *2*a shows evidence of infection. At this stage much of the identity of the shell surface has been lost. Figure *2*b shows the severity of an advanced stage of infection by boring sponges. The brick-red prismatic layer has been completely destroyed on the upper half of the shell and the borings are well into the nacreous inner layer.

A number of mollusk species have similar responses to the activity of *Cliona celata californiana.* Some highly infected shells of *Haliotis rufescens, Hinnites multirugosus*

[E] Editor's note: Figure numbers in *Italics* refer to illustrations on halftone plates, whereas Roman numbers refer to illustrations in the text.

Plate Explanation

A typical process of shell infection by *Cliona celata californiana* on *Haliotis rufescens*. Infection invariably begins in the protoconch area (Figure *1* a) and spreads over the surface of the shell
(Figures *1* b, *2* a, *2* b)

Figure 1 a

5 cm

Figure 1 b

Figure 2 a

5 cm

Figure 2 b

GALE, 1928 and *Mytilus californianus* CONRAD, 1837 were found to be up to 5 times thicker than similar shells with less infection.

The piddock, *Penitella conradi,* belongs to a group of rock and shell borers of the family Pholadidae. This piddock bores into the shells of a number of marine mollusk species, including *Mytilus californianus, M. edulis* LINNAEUS, 1758, most species of *Haliotis, Astraea undosa* WOOD, 1828, and others.

In *Haliotis* species the piddock always enters the shell from the outside and bores at right angles to the shell surface (Cox, 1962). As it bores into the abalone shell and approaches the inner surface, a layer of nacre is secreted over the affected area by the mantle. As the piddock continues to bore, successive layers of nacre continue to coat the area. Eventually, a rounded bulge or blister pearl is formed on the inner surface of the shell (OLIVER, 1916). Figures 3a, 3b show typical blister pearl formations on the inner surface of shells of *H. rufescens.* In Figure 3a, the dark ring at the bottom of the shell was caused by one *Penitella conradi* individual that bored completely through the shell while the abalone was living. In this instance, *P. conradi* may have been the cause of death. Complete penetration was found in only 3% of the shells examined in this study. All other infections by *P. conradi* appeared as those in Figure 3b.

Abalone shells are occasionally hosts to a third group of shell borers, the polychaetous annelids of the family Polydoridae. The polydorid burrows are distinguished from those of the boring sponge and the boring piddock by the characteristic ○○-shaped opening to the burrow. Polydorid burrows occur in only 12% of the shells discussed in this paper. Figures 4a, 4b, and 4c show polydorid burrows exposed on shells of *Haliotis cracherodii.* Notice that the polydorid burrows have also begun in the area of the protoconch (Figure 4a) and have subsequently spread to other areas of the shell (Figures 4b, 4c).

MATERIALS AND METHODS

A total of 90 shells of *Haliotis rufescens* and 165 of *H. cracherodii* were used in this study. Five parameters of each shell were measured: maximum diameter (antero-posterior axis), minimum diameter (lateral axis), shell height (dorso-ventral axis), number of borings by *Penitella conradi,* and percentage of surface area of each shell infected by *Clione celata californiana.* The polydorid polychaete activity was not included because of the low frequency of occurrence.

The shell dimensions were measured with a device consisting of two flat parallel boards mounted vertically on a surface calibrated in millimeters. One of the boards remained stationary, while the other could slide freely across the calibrated surface.

The borings of *Penitella conradi* were counted by examination of the outer surface of the shell and the conspicuous blister pearls on the inner surface The percentage of the surface area of each shell infected by *Cliona celata californiana* was determined by placing a 1.25 mm mesh grid over the shell surface. By counting the squares over the entire shell and the squares over the infected area only, dividing the latter number by the former and multiplying the result by 100, the percentage of infected area was obtained. A re-examination of these procedures revealed an error of less than 5%.

RESULTS AND DISCUSSION

Commensalism is a very common occurrence in the marine environment but is seldom studied in relation to phenomena such as growth and aging. The age-dating of abalones by shell characteristics has long been a problem confronting malacologists and conchologists. The growth rate of abalones has been found to be primarily a function of their distribution. Throughout the geographical range of *Haliotis rufescens,* for example, there are what are known as "fast-growing" and "slow-growing" areas (pers. comm. by Ebert). This means that the ages of two comparably sized shells from two different areas are not necessarily the same.

An additional complicating factor involved with age-dating abalones is the cessation of growth during gonadal maturation. The resumption of growth activity after spawning is then directed at building either shell increment or body mass, but not simultaneously. The order and extent of these activities are primarily on an individual basis (pers. comm. by Montgomery).

SAKAI (1960) described growth rings corresponding to annual gonad maturation in *Haliotis discus hannai* INO, 1952. However, the first spawning season of the young abalone and the growth increments established before that time varied with local conditions.

The percentages of occurrence of *Penitella conradi* and *Cliona celata californiana* on shells of *Haliotis rufescens* and *H. cracherodii* are listed in Table 1. These data indicate a nonpreference of *C. celata californiana* to either *H. rufescens* or *H. cracherodii,* and a significant preference of *P. conradi* for shells of *H. rufescens.*

Table 1

FREQUENCY OF COMMENSALS

Commensal	Frequency of Occurrence on	
	Haliotis rufescens	*Haliotis cracherodii*
Cliona celata californiana	81%	79%
At least 50% of shell surface infected by *Cliona celata californiana*	32%	20%
Penitella conradi	42%	25%
Polydorid polychaetes	11%	12%

Infection by *Penitella conradi*

MEREDITH (1968) reported *Penitella conradi* found in the lower 2 feet of a 7 foot intertidal mussel bed. Since *P. conradi* was not found in the upper 5 feet of the mussel bed, the upper limit to the vertical distribution of *P. conradi* must be in the lower intertidal zone. The vertical distribution of *Haliotis cracherodii* extends well above the lower intertidal zone. Therefore, individuals above the lower intertidal zone should be free from attack by *P. conradi*. This observation was confirmed by field investigations at Año Nuevo Island, Pigeon Point (San Mateo County) and Point Pinos (Monterey County). The frequency data, therefore, should show a significant preference of *P. conradi* for *H. rufescens*, a sublittoral species.

Figure 5 is a comparison of the mean infection rates of *Penitella conradi* with shell size of *Haliotis rufescens* and *H. cracherodii*. The size index, derived from the sum of the maximum diameter, the minimum diameter, and the height for each shell, was found by far the best criterion on which a number of shells of either species of abalone could be sorted on a scale indicative of successive ages.

Individuals of both *Haliotis cracherodii* and *H. rufescens* smaller than size index 15 had no signs of attack by *Penitella conradi*. Beyond this size, the regression of the number of *P. conradi* per shell increased linearly with increasing shell size index. The 95% confidence limits estab-
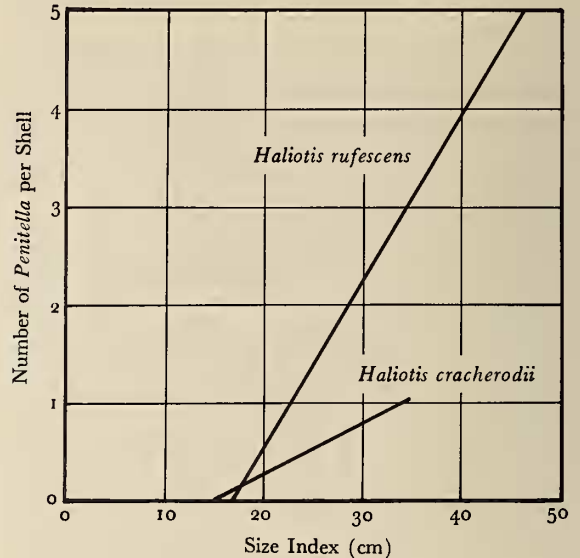

Figure 5

Regression lines of numbers of *Penitella conradi* against the size index of *Haliotis rufescens* and *Haliotis cracherodii*

lished on the regression analysis of these data indicated a significant difference existed between the regression lines of the two species of abalones. The difference was attributed to the lack of *P. conradi* on individuals of *H. cracherodii* from above the lower intertidal zone.

Infection by *Cliona celata californiana*

The regressions of the shell surface areas infected by *Cliona celata californiana* are shown in Figure 6 as functions of shell size index of *Haliotis rufescens* and *H. cracherodii*. Again, no infection was evident below size index 15. In either case of infection by *C. celata californiana*, the regression of infected shell area was a logarithmic progression with the abalone shell size index. This relationship indicated that the infected area was the result of the initial attachment and subsequent proliferation of a

Plate Explanation

Figure 3: Infection by *Penitella conradi* on *Haliotis rufescens*. A black ring marks the shell (Figure 3a) where *P. conradi* had bored through the nacreous shell layer of the living abalone, a variation from the more common blister pearl (Figure 3b)

Figure 4: Successive ages of *Haliotis cracherodii* (Figures 4a, 4b, 4c, respectively) show burrows of polydorid polychaetes centered around the protoconch area